Space Weather Technical Forecast

Issued on Sunday 15 December 2024 at 13:03 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Isolated R1/R2 radio blackouts likely at first.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low activity with a peak C8.2 flare observed at 15/1107 UTC. There are currently six sunspot regions on the Earth-facing disc. AR3917 is approaching the southwestern limb and as such any detail is becoming harder to see, with no change made to its classification. AR3924, in the south-centre disc, is the most developmental region at this time, with a mature leading region formed and numerous trailing spots of smaller size that have recently began grouping together. AR3920 and AR3925 have both remained fairly stable. After fading from view over the past day or so, AR3922 in the southeast has now reformed, but is currently a simple bipolar region. A new region has rotated around the southeastern limb, currently appearing to be a simple unipolar region.

A CME associated with a filament eruption in the southwest of the disc at 14/2240 UTC is expected to pass mostly ahead and below Earths orbit, although it may give a glancing blow with Earth later on the Day 3 (17 Dec) or early Day 4 (18 Dec).

Solar Wind / Geomagnetic Activity: Solar winds, as reported by ACE at L1, indicated an ongoing slow wind regime until around 15/0740UTC at which point a weak transient CME may have been observed. Solar wind speeds were at background, typically varying between 300-350km/s, but became slightly elevated from 15/0740UTC, peaking at 420km/s at 15/1007UTC. Density was generally around average, but became below average for a time from 15/0740UTC. The Interplanetary Magnetic Field (IMF), Bt, was moderate. The north-south component, Bz, oscillated between positive and negative, but favoured a weak negative direction, but became moderate at times. Over the whole period it varied between +6/-10nT. The phi angle was positive (away from the Sun). The net result of the above solar wind measures was for Quiet to Unsettled geomagnetic activity.

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at Background levels.

High energy electron flux (greater than 2MeV) observed by GOES16 was initially moderate, but fell to background by 14/1800UTC. The associated 24-hour fluence was below Active, and slowly declining. The 15/0000 UTC observation was 7.1e6 integrated pfu.

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Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is likely, with isolated M-class flares. There is a slight chance of isolated X-class flares.

Solar Wind / Geomagnetic Activity: A CME associated with a filament eruption in the southwest of the disc at 14/2240 UTC may give a glancing blow with Earth later on Day 3 (17 Dec) or early Day 4 (18 Dec). A connection to a HSS from CH99/+ is expected to continue through Day 1 (15 Dec).

Geomagnetic activity is most likely to be in the Unsettled to Active range through Day 1, with a slight chance of G1 Minor Storm intervals, before easing back to background into the new UTC working week. Activity may then become unsettled to active again late Day 3 or early Day 4, with a chance of G1 Minor Storm intervals, in association with the CME from the filament eruption late on the 14 Dec.

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at Background, but with a daily slight chance of rising in response to any notable flares.

High energy electron flux is expected to be generally at background to moderate levels. The 24-hour fluence is expected to remain below the Active threshold.

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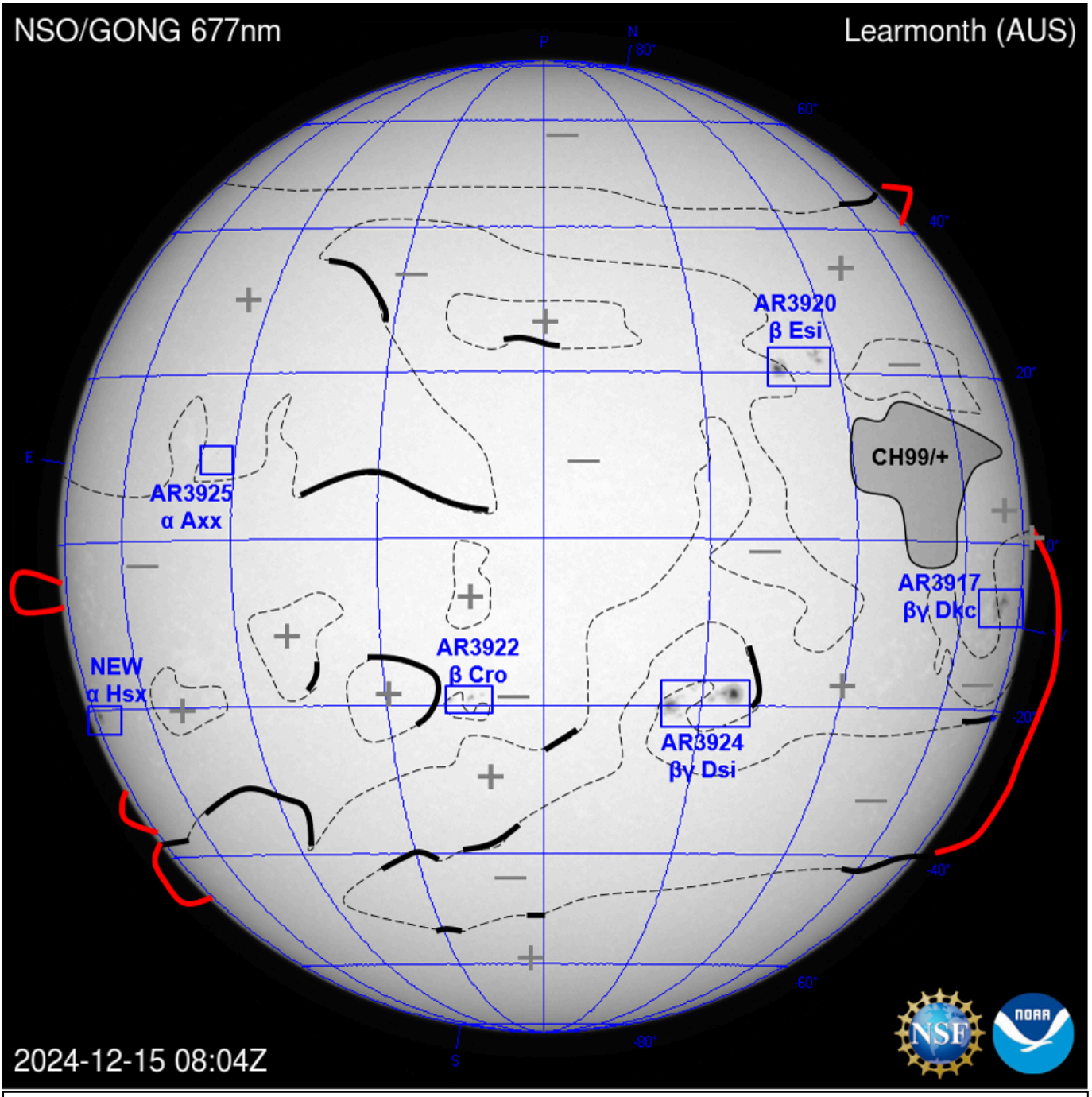
Figure 1: Solar Synoptic Map valid 15/0800 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

A CME associated with a filament eruption in the southwest of the disc at 14/2240 UTC is expected to pass mostly ahead and below Earths orbit, although it may give a glancing blow with Earth later on the Day 3 (17 Dec) or early Day 4 (18 Dec). However due to ongoing imagery gaps and the large numbers of minor events on the disc, it is possible there could be some influence from unmodeled, weak transient CMEs over the coming days, but this is low confidence.

The coronal hole-based forecast is relatively higher confidence. Slightly enhanced geomagnetic activity has been observed, most likely as a result of a connection to a HSS from coronal hole CH99/+, situated in the western hemisphere. This is a persistent feature, and was likely the cause of a weak enhancement that occurred on the previous rotation on 18 Nov with peak wind speeds of around 450km/s. This feature is expected through Day 1 (15 Dec) and may be the cause of current slightly enhanced wind speeds of around 410 km/s, but this may also be due to a transient CME which was observed at L1 around 15/0750 UTC.

Activity is most likely to be in the Unsettled to Active range through Day 1, with a slight chance of G1 Minor Storm intervals, before easing back to background into the new UTC working week. Activity may then become unsettled to active again late Day 3 or early Day 4, with a chance of G1 Minor Storm intervals, in association with the CME from the filament eruption late on the 14 Dec.

MOSWOC ENLIL output brought in a connection with the HSS from CH99 earlier than forecast, hence its decrease in solar wind speed through 15 Dec is expected to occur too readily. The more noticeable enhancement in MOSWOC ENLIL occurring late on Day 1 (15 Dec), which is too late to be from CH99 and has no observable source region currently on this disc. This is consequently considered anomalous and disregarded at this stage.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	20	5	30	1
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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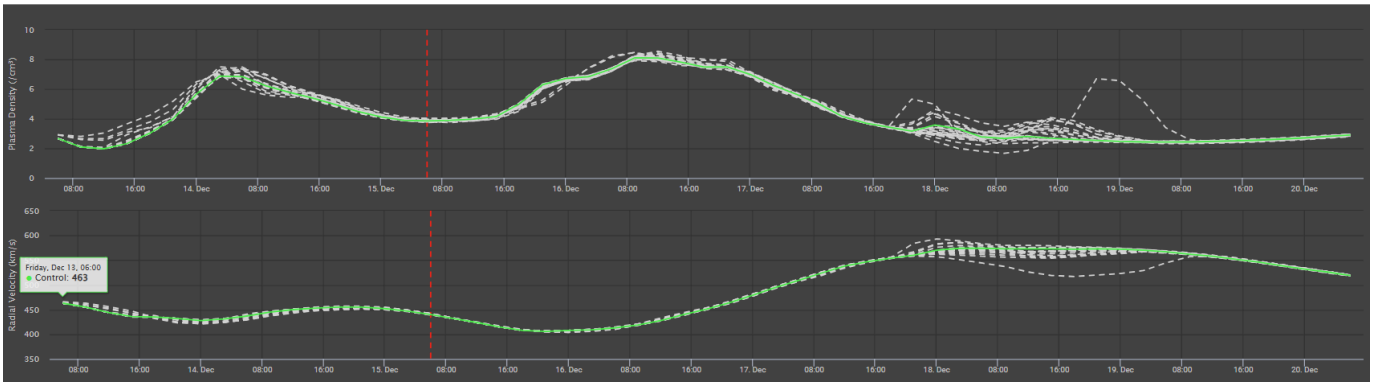
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
15/12/2024 09:02	Partial	Filament	SW	516	17/12/2024 2300 +/- 8 hrs	CME associated with large filament disruption from the SW disc at 14/2240

Figure 2: MOSWOC ENLIL ensembles showing some CME influence from late on the 17 Dec.



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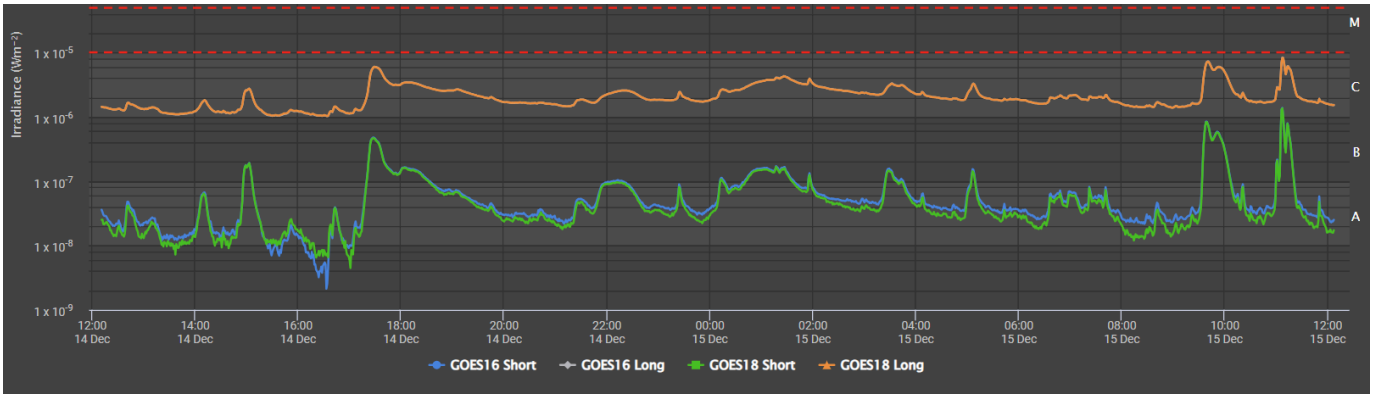
Radio Blackouts - X-Ray Flares

Solar Activity is currently Low with a peak C8.2 flare observed at 14/1107 UTC. There are currently six sunspot regions on the Earth-facing disc. AR3917 is approaching the southwestern limb and as such any detail is becoming harder to see, with no change made to its classification. AR3924, in the south-centre disc, is the most developmental region at this time, with a mature leading region formed and numerous trailing spots of smaller size that have recently began grouping together. AR3920 and AR3925 have both remained fairly stable. After fading from view over the past day or so, AR3922 in the southeast has now reformed, but is currently a simple bipolar region. A new region has rotated around the southeastern limb, currently appearing to be a simple unipolar region.

Regarding the evolution of sunspot regions in the four days, AR3917 will begin to cross the western solar horizon from Day 2 (16 Dec) onwards. There also continues to be the potential for further regions to rotate onto the disc from over the east limb (perhaps corresponding to Ex-AR3911 and Ex-AR3901), with some clear magnetic structure evident on e.g. GOES SUVI 171. Overall we maintain a likelihood of isolated M-class flares with a persistent slight chance of isolated X-class flares, reducing slightly through the period as AR3917 rotates around the western limb.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	No	55	55	40	40
Very Active	R3-R5 (X Class)	No	10	10	5	5

Figure 3: GOES-16 & -17 X-ray flux



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Solar Radiation Storms (High Energy Protons)

GOES18 proton flux carries a daily slight chance of a response from any significant solar flares. Enhancement most likely from AR3917, which despite showing some signs of simplification and consolidation in extent maintains the risk of a significant flare. The risk is maintained throughout the forecast period, even as AR3917 rotates around the western limb.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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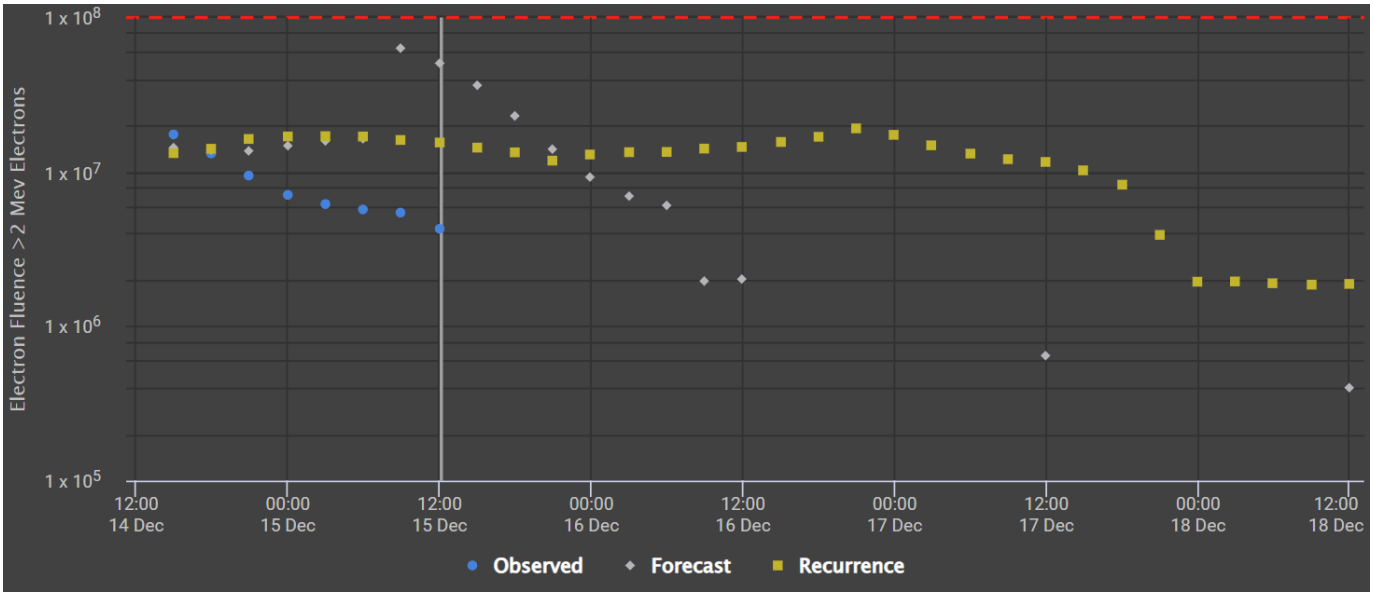
High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has varied between background and diurnally moderate levels. Observed flux is likely has now dropped out as a consequence of the increased solar wind pressure from CH99/+. Electron flux may recover back to moderate for a time in Day 2 (16 Dec), before reverting to background levels again from late Day 3 due to a potential glancing CME arrival.

The associated 24-hour fluence is well below the Active (1e8 integrated flux) threshold, on a declining trend. This is expected to continue through much of the period which is supported by REFM.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^8	No	1	1	5	5
Very Active	≥ 2 MeV ≥ 1×10^9	No	1	1	1	1

Figure 4: MOSWOC REFM



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